Improving Ground Motion Attenuation Relation in the Great Basin

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Progress Report

The objective of this project is to develop ground motion attenuation relations suitable for the Great Basin by constraining path effect using empirical and synthetic data from the Great Basin and by constraining source effect using source parameters derived from events of extensional environment. For the year of 2003-2004, we have focused our efforts on (1) further validating and improving our numerical procedure for synthetic strong motion simulation, (2) understanding the effect of fault type, magnitude, distance, directivity, static stress-drop, depth of asperity, and Hanging wall/foot wall effects, and (3) collecting data for proposed source study of earthquakes under extensional environment using validated ground motion simulation procedures.

To further validating our numerical simulation procedures, we have carefully studied six relatively well-recorded M>6.5 earthquakes, namely the 1971 Imperial Valley earthquake, the 1989 Loma Prieta earthquake, the 1992 Landers earthquake, the 1994 Northridge earthquake, the 1995 Kobe earthquake, and the 1999 Kocaeli earthquake. We used the composite source simulation procedure (Zeng et al., 1994) to calculate the synthetic ground motions at all the collected stations. Figure 1 plots the misfit between the observation and synthetic prediction for the horizontal components for the Northridge earthquake. The misfit is quantified in terms of biases (upper panel) and standard errors (lower panel) over a broad frequency range. The middle line in the upper panel of Figure 1 shows the biases versus frequencies with the 90% confidence level envelopes of the biases. The comparison between synthetics and observations suggests that the composite source model has provided an unbiased broadband kinematic description of the earthquake source rupture. To examine the trend of the fit over distance range, we have computed the synthetic ground motions of the Northridge earthquake at 150 strong motion stations. Figure 2 shows the result in comparison with the observed and regression prediction (Abrahamson and Silva, 1997) for PGA and SA at 3 second. The synthetic simulations clearly predict the trends of attenuation of the observed ground motion parameters over distance. The values plotted at the upper right corner of the figures are the standard errors of the prediction from the composite source model and from Abrahamson and Silva's regression respectively. At long period, our synthetic procedure outperformed the regression prediction in terms of both standard errors and distance attenuation rate. Scatters in the data are caused mainly by local site and basin responses.

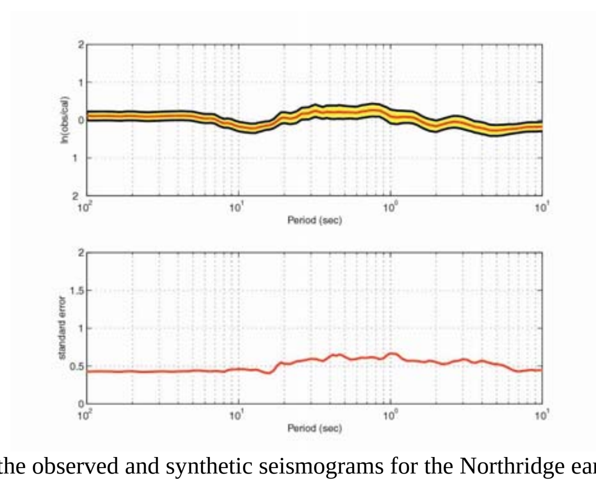

Figure 1. Misfit between the observed and synthetic seismograms for the Northridge earthquake. The upper panel shows the biases (red) and its 90% confidence limits (black) for the horizontal components. The lower panel shows the standard errors.

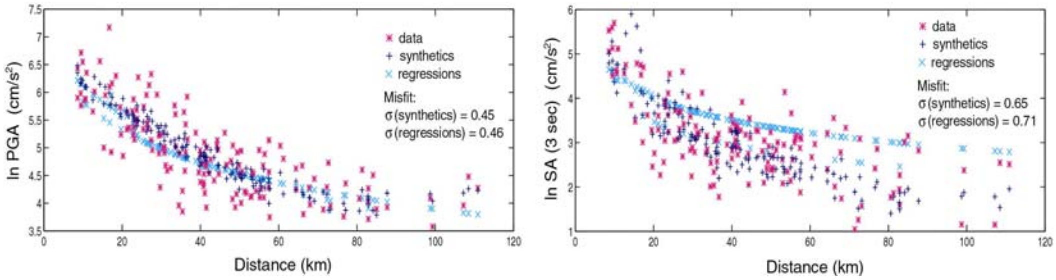

Figure 2. Comparison between observed and predicted peak ground motion parameters for the 1994 Northridge earthquake. The left panel is for the peak ground acceleration and the right panel is for the spectra acceleration with 5% damping at 3 second period.

We have calculated the same misfits as that of Figure 1 but for the Imperial Valley, Loma Prieta, Landers, Kobe, and Kocaeli earthquakes, respectively. In general, we find the simulations are unbiased and the standard errors for all the events are about 0.5 in average across the validation period range. Given those earthquake magnitudes, the results also demonstrate that our ground motion simulation procedure is unbiased for the magnitude range from 6.5 to 7.3.

With the confidence provided by the above validations, we have computed scenario ground motion simulations for the magnitude range from 6.5 to 8.5 at distances from 0 to 200 km. From those simulations, we found the effect of shallow and deep asperities is small. We found large scatters in the synthetic distance attenuation caused by rupture directivity effects and it increases as period increases. One interesting observation in the distance attenuation is effect of the critical Moho reflection. For peak ground acceleration, we found the effect is negligible. At 1 second period, it creates a shoulder in the ground motion attenuation at distance between 60-100 km. At 3 second period, the shoulder moves to 100-140 km. For 10 second, it moves to 100-200 km. Our interpolation is that the Moho reflection affects the attenuation around 1 second period. For 10 second period, surface waves start to dominate over body waves. For 3 second period, it is a mixed effect of Moho reflection and surface wave generation. We are still in the process of understanding the effects of directivity, static stress-drop, depth of asperity, and Hanging wall/foot wall.

We have collected most of the following earthquake data appropriate for extensional provinces:

1940 Imperial Valley, CA earthquake, M=6.87
1979 Valnerina, Italy earthquake, M=5.90
1980 Mammoth Lakes, CA earthquakes, M=5.70-6.20
1980 Victoria, Mexico earthquake, M=6.32
1980 Irpinia, Italy earthquakes, M=6.20-6.87
1981 Westmoreland, CA earthquake, M=5.90
1983 Borah Peak, ID earthquakes, M=5.10-6.90
1984 Lazio-Abruzzo, Italy earthquake, M=5.80
1986 Chalfant Valley, CA earthquakes, M=5.60-6.30
1986 San Salvador, EL Salvador earthquake, M=5.76
1987 Edgecumbe, NZ earthquakes, M=5.80-6.60
1992 Erzincan, Turkey earthquake, M=6.70
1994 Double Spring Flat, NV earthquake, M=5.90
1995 Kozani, Greece earthquakes, M=5.10-6.60
1995 Gulf of Aqaba earthquake, M=7.20

We are in the process of developing parallel computing procedures to facilitate our earthquake source analysis. Results from this source analysis will be combined with the result from our studies of local and regional seismic wave propagation for the Great Basin area to simulate scenario ground motions useful for developing ground motion attenuation relations using combined empirical and synthetic data from the Great Basin. The result from this project will directly contribute to the prediction of strong-ground motion and seismic hazard assessment in the Great Basin.

References

Abrahamson, N. A. and W. J. Silva (1997). Empirical response spectral attenuation relations for shallow crustal earthquakes. *Seism. Res. Lett.* **68**, 94-127.

Zeng, Y., J. G. Anderson and G. Yu (1994). A composite source model for computing realistic synthetic strong ground motions, *J. Res. Lett.*, **21**, 725-728.

BUDGET FOR 2nd YEAR

Project Title: Improving Ground Motion Attenuation Relation in the Great Basin

Principal Investigator(s): Yuehua Zeng and Feng Su

COST CATEGORY	Federal First Year	Federal Second Year[2]	TOTAL Both years[2]
1. Salaries and Wages	$	$	$
Total Salaries and Wages	$	$28,167	$28,167
2. Fringe Benefits/Labor Overhead	$	$7,605	$7,605
3. Equipment	$	$	$
4. Supplies	$	$1,400	$1,400
5. Services or Consultants	$	$	$
6. Radiocarbon Dating Services	$	$	$
7. Travel	$	$2,000	$2,000
8. Publication Costs	$	$1,500	$1,500
9. Other Direct Costs	$	$	$
10. **Total Direct Costs (items 1-9)**	$	$40,672	$40,672
11. Indirect cost/General and Administrative (G&A) cost	$	$18,302	$18,302
12. Amount Proposed (items 10&11)	$	$58,975	$58,975
13. Total Project Cost (Total of Federal and non-Federal amounts)	$	$	$58,975

[1] This form shows the format of the budget summary. Use this sheet for the Budget Summary, which precedes the detailed budget. The detailed budget must be keyed directly to the Budget Summary page.

2 These Columns only for multi-year projects

NEHRP Proposal Improving Ground Motion Attenuation Relation in the Great Basin

Proposed start date: 15-Nov-03 Budget Prepared:Nov 15, 2004

Year Two Total: 58975

SALARIES

Employee	Units	Rate	Number	Subtotal	Benefit Ra	Benefits
Yuehua Zeng	Monthly	6630	3	19889	0.27	5370
Feng Su	Monthly	5519	1.5	8278	0.27	2235
John Anderson	Daily	655	0	0	0.04	0
Student-Academic Yr	Monthly	1000	0	0	0.02	0
				28167		7605

Total Salary and Fringe			35772
Equipment Total			0
Consultants Total			0
Expendables			2900
	Office Supplies	100	
	Computer Time, Supplies	1000	
	Telephone Line & Long Distance	300	
	Publication Costs	1500	

Travel	Dest	Per trip	N. Trips	Subtotal	Total:	2000
	SSA meeti	1000	1	1000		
	AGU meet	1000	1	1000		

			Number	
Additional Student Expenses				
	Tuition and Fees per semester	2680	0	0

Total Direct Cost			40672
Indirect Cost Computation			
	Total Direct Cost	40672	
	Subtract Tuition & Fees	0	
	Subtract Equipment	0	
	Adjusted Total	40672	
	Fraction	0.45	
	Indirect Cost		18302
Year Two Total			58975